

EROSION AND ACCRETION OF SELECTED HAWAIIAN BEACHES, 1962-1972

by

J. H. CAMPBELL

NOVEMBER 1972

Prepared under the
NATIONAL SEA GRANT PROGRAM
National Oceanic
and
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The University of Hawaii Sea Grant Program

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ABSTRACT

Sixty Hawaiian beaches were surveyed in 1972 as part of the University of Hawaii Sea Grant Program. For 33 of them, the volume of sand and width of the beach could be compared with earlier measurements to indicate trends of erosion over a decade of time. The measured volumes and beach width are presented in tables. Surveillance on Kauai, Molokai, and Maui was conducted in winter and in summer; on some Oahu beaches it was monthly, and on others, quarterly.

For many beaches there was no significant gain or loss in volume of beach sand; this general conclusion appears to be true for the islands as a whole. At the following beaches, some long-term gains were evident: Kalihiwai, Poipu, Kokole Point, Waiokapua Bay, and Hanalei Bay (Kauai); Punaluu, Lanikai, Kahala, Ewa, and Waialua (Oahu); Onealii (Molokai); and Hana, Kaanapali, and Waiehu (Maui). Some degree of erosion occurred at: Kekaha and Haena (Kauai); Hauula, Makapuu, and Sunset (Oahu); Kapukawahine and Kamakaipo (Molokai); Hamoa, Olowalu, Napili, Flemings Beach, and Sprecklesville (Maui); and Kaimu and Punaluu (Hawaii). About half of this latter group have a chronic history of erosion and about half are newly identified.

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	iii
TABLE OF CONTENTS	v
ILLUSTRATIONS	vii
Introduction	1
Scope of the Project	3
Beach Volumes and Changes	5
General:	
Kauai	6
Oahu	11
Molokai	15
Maui	19
Hawaii	24
Long-Term Changes	24
Acknowledgments	29
References Cited	30

ILLUSTRATIONS

Figure		Page
1.	Selected beaches, Kauai	7
2.	Selected beaches, Oahu	12
3.	Selected beaches, Molokai	16
4.	Selected beaches, Maui	20
5.	Selected beaches, Hawaii. Kaimu and Punaluu are black-sand beaches	25
6.	Size of selected beach-sand reservoirs, Hawaiian Islands. Measurements of 1962-63 compared with those of 1971-72	28

Table

1	Beach volumes, selected beaches, Kauai.....	8
2	Beach widths, selected beaches, Kauai	9
3	Beach volumes, selected beaches, Oahu	13
4	Beach widths, selected beaches, Oahu	14
5	Beach volumes, selected beaches, Molokai	17
6	Beach widths, selected beaches, Molokai	18
7	Beach volumes, selected beaches, Maui	21
8	Beach widths, selected beaches, Maui	22
9	Beach volumes, black-sand beaches, Hawaii	26
10	Beach widths, black-sand beaches, Hawaii	27

INTRODUCTION

During 1962 to 1964 the Hawaii Institute of Geophysics (HIG) staff compiled observations and quarterly measurements of Hawaii's shorelines and coastal geology (Moberly, 1963; Moberly and Chamberlain, 1964; Moberly et al., 1965; Moberly, 1968; Chamberlain, 1968). After completion of that work, it was recommended that a continuing program of beach measurements be undertaken to monitor changes in the beaches and thus permit prediction of erosion problems. Since then there has been no overall shoreline surveillance program, although specific areas have been studied by the U. S. Army Corps of Engineers, the State of Hawaii, and local agencies. In 1969, a major State planning report through the Governor's Task Force on Oceanography included the recommendation that a beach surveillance program be reinitiated by the State of Hawaii (Perry et al., 1969).

In late 1970, through the Sea Grant program in Coastal Zone Management federal funds became available to commence planning a new shoreline surveillance program. HIG staff members who had worked on the original study went into the field to determine how many of the previously studied beach ranges could be reestablished, and to make preliminary measurements and observations.

In September 1971, funds became available (Sea Grant 2-35243) for a surveillance program. However, due to limitations of the grant, it was decided to concentrate on the islands with the largest number of beaches. Lanai and Hawaii

were thus excluded. Niihau was also excluded, not because of a lack of beaches, but because of its limited access and small population. Lanai has only a few good beaches and its population is small 'also. Because the island of Hawaii has only a few good beaches, they get heavy usage, and for this reason Hawaii should have been restudied; however, time and cost consideration did not permit it.

In mid-1972; the University received word that the granting agency (NOAA) would not continue to support the Hawaii surveillance project, and so the summer 1972 field work and subsequent data calculations were designed to terminate after a year's study.

This report summarizes those aspects of the present work that can be compared directly with the earlier measurements. All additional data, such as locations of cemented metal range-markers, sand samples, fathometer profiles, and surveying data, will be stored at HIG and will be available upon request.

Scope of the Project

Although we could not match the scope of the 1962-1964 work, we did remeasure the physical characteristics of previously-studied beaches and compared these data with those collected in the early 1960's.

Of the 70 beaches previously studied on Kauai, Oahu, Molokai, and Maui, we were able to reoccupy the same ranges (lines of topographic survey across the beach and shallow water) on 33 of them; these will be the major subject of this report. New ranges were established on 24 other beaches that had been studied in 1962-1964--in the event that future funding allows continuation of this work (Figures 1-5). Twelve of the earlier ranges were not remeasured for various reasons. Added were a new range at Kaaawa, Oahu, where an erosion problem has been reported, and two ranges near Bonham Air Field on Kauai, which had been the subject of a 1968 HIG study.

Earlier work (Moberly and Chamberlain, 1964) pointed out that Hawaiian beaches are part of littoral cells (self-contained natural coastal segments) that include underwater sand reservoirs as well as the exposed beach-sand reservoir, all influenced by changing waves, currents, and wind. Thus, any comprehensive study of a shoreline segment requires surveys of each of these factors, as well as gains or losses of sand in the cell, over as long a time-span as possible. Because such surveys would have exceeded the financial and

temporal scope of the grant, the major effort went into determining changes in the onshore beach volumes. It is generally assumed that such changes reflect what is happening to the total littoral cell.

Variation in beach width by lateral erosion or accretion is probably the most readily apparent change. Although certainly of importance wherever man-made structures on the beach may be destroyed by erosion, this change may not be truly representative of changes in the entire system. For example, if wave conditions are such that the berm height is increased by movement of sand up onto the back beach during erosion of the foreshore, the beach width can vary greatly without significant change in the volume of the beach reservoir.

Drift of sand from one part of the beach to another along the shore, and from onshore to offshore reservoirs, is also important and measureable, and a modest effort was included in the project. However, determining the onshore volume of beach sand offered the maximum predictive and scientific information for the available funds.

Topographic profiles surveyed across the beaches, along ranges established near the mid-point of the beach length, were part of the volume calculation. The cross-sectional area at mid-beach bounded at the sand-air interface by the beach topography and at the base by bedrock or some arbitrary depth in the sand--multiplied by the beach length--gives the

approximate volume. Admittedly, the cross-sectional areas vary where the beach locally widens or narrows, or where rocks crop out, etc., but for most Hawaiian beaches such variations are minor compared to seasonal or long-term changes at mid-beach.

The beach volumes reported earlier (Moberly and Chamberlain, 1964) had been calculated manually using a planimeter over a drafting of the cross-sectional area that included all sand down to bedrock or to an arbitrary lower boundary. Because the records indicating the lower boundary position were ambiguous for some beaches, it was not possible to calculate present-day volumes so that they can be compared directly with former volumes. The original topographic and bedrock survey data remained, however, and by assigning the same arbitrary lower boundary to both the old and the new measurements it was possible to calculate volumes that could show seasonal and long-term changes. Mean lower low water (MLLW), which is the topographic datum in the Hawaiian Islands, was selected as the boundary. All volumes were then calculated by computer.

Beach Volumes and Changes

General

Beach volumes and widths on the islands of Kauai, Oahu, Molokai, Maui, and Hawaii are given in Tables 1 through 10.

Although there is general agreement between the two kinds of measurements, it can be noted that for about one-third of the measurement periods there is no correlation between the time of maximum width of an individual beach and time of maximum volume, nor times of minimum width and volume.

KAUAI

Figure 1 shows the location of beaches measured on Kauai, Table 1 gives the volume of the beach sand reservoirs and Table 2 gives the beach widths. There follows a brief description of the changes at each beach.

Kalihiwai measurements show a definite increase in beach volume over the earlier data. Both the winter and summer measurements showed the beach to be larger than at any time in the past.

Poipu also shows an increase in beach volume; volume during both the winter and summer of 1972 was greater than at any time during the 1962-63 period.

Kekaha shows a loss in volume. This is not surprising, as erosion has been a continuing problem; at the center of the beach, 110 feet of lateral erosion has occurred during the 30 years preceding 1966, according to the U. S. Army Corps of Engineers. Rock dumped on the beach side of the highway has protected it from further erosion, but the highway still has to be closed during periods of high waves when water washes over it.

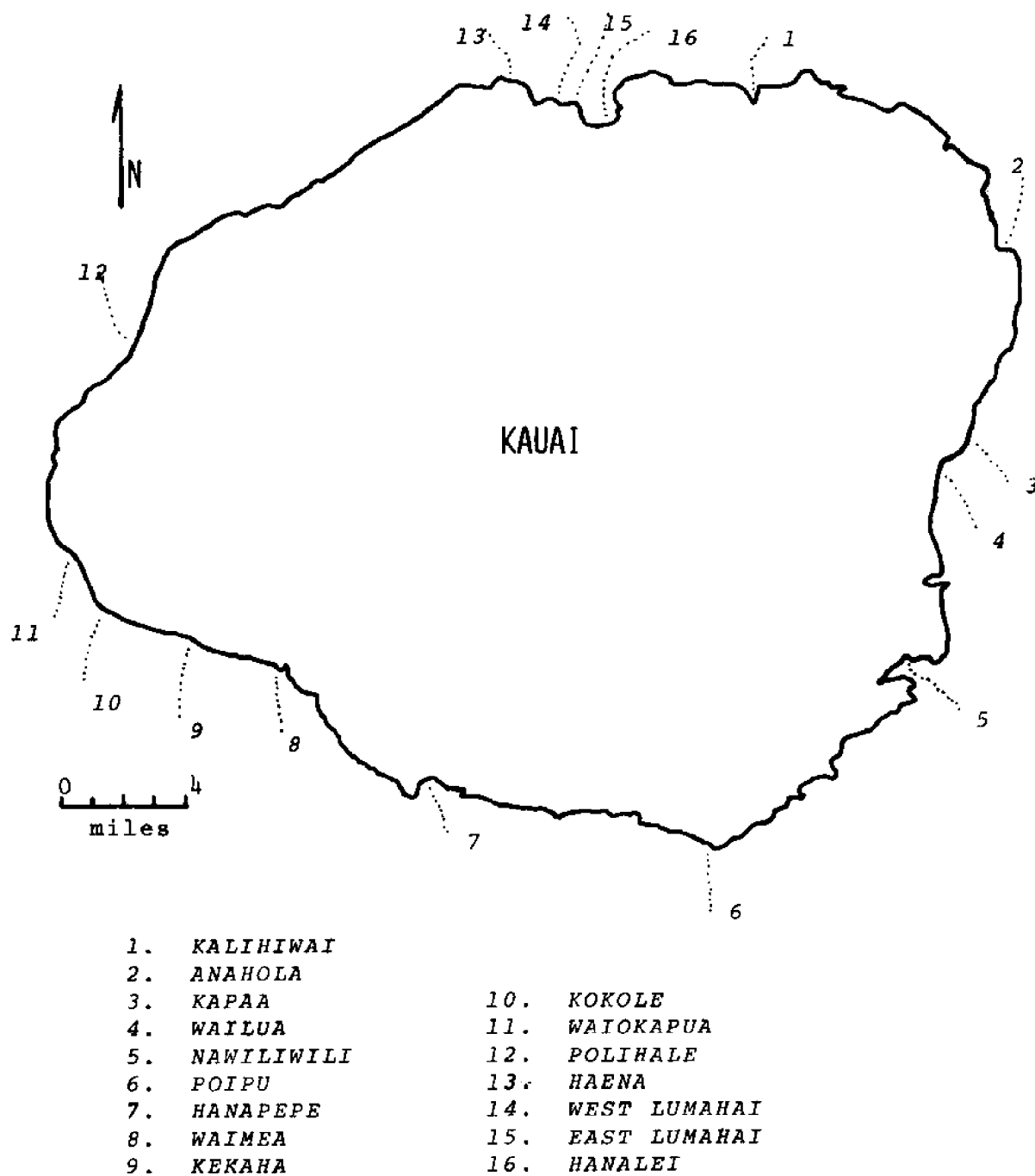


FIGURE 1. Selected beaches, Kauai.

TABLE 1. BEACH VOLUMES, SELECTED BEACHES, KAUAI

Beach	Volume in 10^3 yd^3							
	5/62	8/62	11/62	2/63	5/63	7-8/63	1/72	5/72
Kalihiwai	53.8	60.2	47.3	34.3	70.2	73.0	70.2	91.6
Poipu	11.2	6.2	6.5	9.7	10.4	10.5	11.4	11.9
Kekaha	158.2	96.3	82.6	292.4	149.4	130.6	43.2	99.3
Haena	104.9	112.4	114.5	104.1	116.1	122.8	97.3	98.7
Lumahai (W)	417.6	449.0	270.8	100.5	291.0	358.1	385.4	359.4
Hanalei	471.0	499.8	384.0	337.9	358.0	404.5	449.1	501.7

TABLE 2. BEACH WIDTHS, SELECTED BEACHES, KAUAI

Beach	5/62	8/62	Width in feet at MLLW				7-8/63	1/72	5/72
			11/62	2/63	5/63				
Kalihiwai	202	192	140	90	196	195	178	210	
Poipu	90	70	62	70	82	83	76	85	
Kekaha	107	71	64	265	103	94	45	73	
Haena	224	250	250	237	240	260	236	233	
Lumaha'i (W)	481	508	311	130	444	470	468	496	
Hanalei	311	292	219	175	188	220	273	288	

From October 1967 to October 1968 and again in December 1969, after a period of high waves earlier that month, a team from HIG measured several beaches in the vicinity of Bonham Air Field. This present study remeasured two of them--one at Kokole Point and the other at the mid-point of Waiokapua Bay--both show an increase in volume over comparable periods in 1968.

Haena shows a loss of sand over the 1962-63 period, with both the summer and winter 1972 volumes smaller than any previously measured. Part of the loss is due to the disappearance of a large berm that fronted the beach park. This may have happened in the December 1969 storm that damaged coastal private property about a mile to the west.

The west end of Lumahai Beach shows no significant change; the summer 1972 volume measurement is similar to measurements for 1962 and 1963. The winter 1972 volume is much greater than the winter 1963 volume; however, February 1963 can not be considered as a typical period; there had been a bad period of erosion which completely removed the beach and eroding back into the dunes and old vegetated beach ridges.

Hanalei shows an increase in the volume of the beach sand reservoir.

OAHU

Figure 2 shows the beaches that were measured on Oahu, Table 3 gives the volume of the beach sand reserves and Table 4 the beach widths.

Measurements of the beach at Hauula Beach Park show a loss of sand compared with the early 1960 measurements.

Punaluu shows a increase in beach volume, as does Lanikai Beach.

Makapuu shows a tendency toward a decrease in total beach volume, with one exception--the month of March--which showed an increase in 1972 over the 1962 volume.

Kahala shows an increase in volume.

Ewa Beach shows an increase in volume since the early 1960's.

Pokai Bay shows a slight increase. Since sand is occasionally trucked away from the area of the boat ramp at the south end of the beach and replaced in the center of the beach, these measurements can not be used to predict natural movements.

Volume at Makaha has remained fairly constant. There was severe erosion during the storm in late 1962 when the bathhouse was damaged, and the beach was still building back out at the end of the original survey in 1963. The recent measurements show volumes similar to those prior to the 1962 erosion.

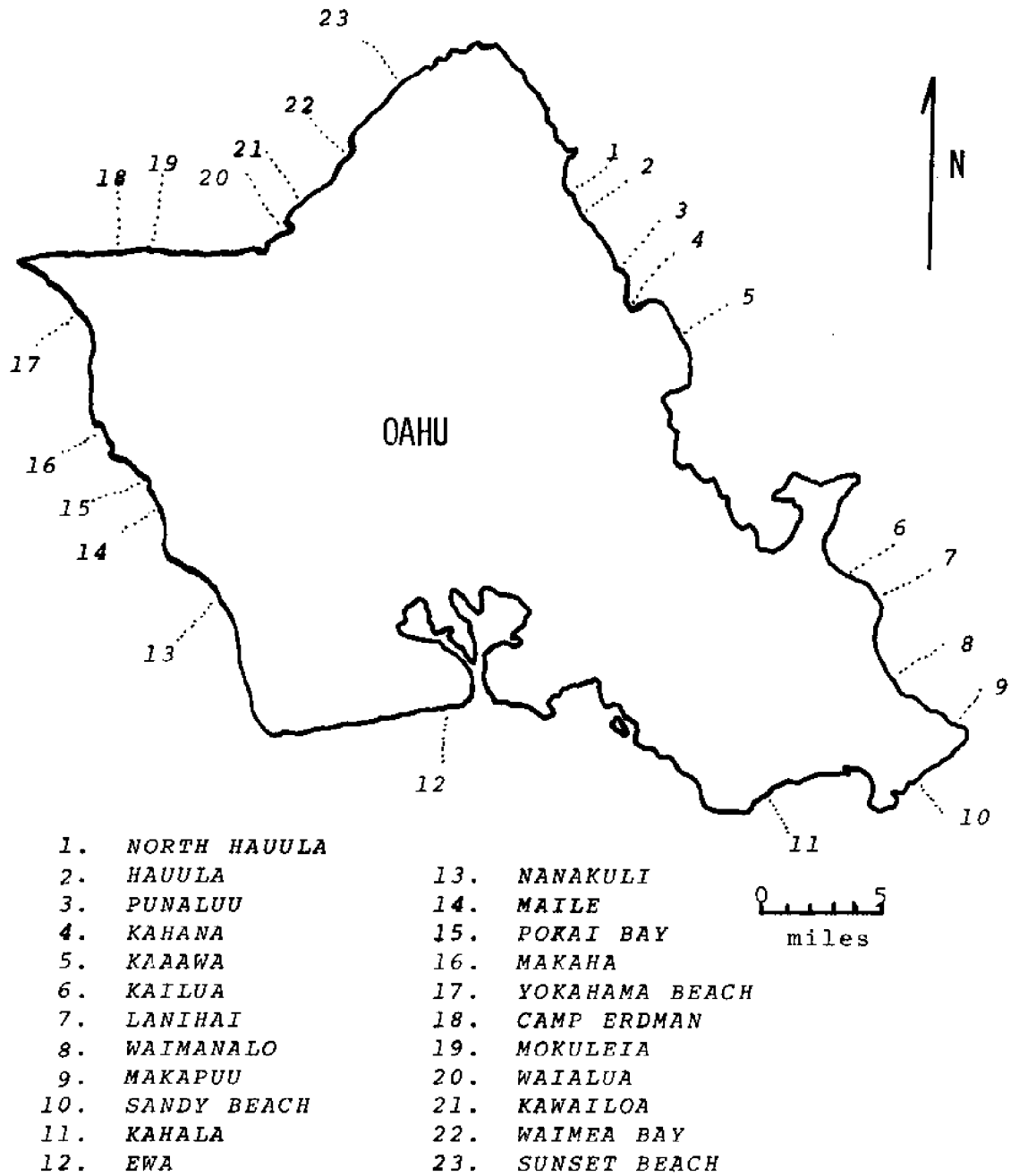


FIGURE 2. Selected beaches, Oahu.

TABLE 3. BEACH VOLUMES, SELECTED BEACHES, OAHU

Beach	Volume in 10 ³ yd ³						
	3-5/62	6-8/62	10-11/62	1-3/63	4-5/63	8/63	9-11/71
						1-3/72	6-7/72
Hauula		17.0	14.5	14.0	12.9	14.8	11.8
Punaluu		37.2	29.3	35.0	27.6	31.5	39.4
Lanikai	68.9	74.8	72.3	72.2	35.2	82.1	88.2
Makapuu	14.8	23.9	29.2	24.5	7.3	14.0	8.4
Kahala		17.8	15.8	17.2	16.8	18.3	32.4
Ewa	158.5	184.0	165.1	118.8	119.0	134.4	193.7
Pokai Bay	26.7	29.8	29.5	28.9	28.1	32.2	30.3
Makaha	130.2	152.0	121.6	26.0	55.6	88.8	153.0
Camp Erdman		119.6	78.1	105.7	89.7	93.9	98.5
Waialua		4.0	3.6	4.6	5.1	5.0	6.6
Kawaiiloa		55.8	37.0	41.0	53.5	46.8*	47.3
Sunset	208.5	338.1	240.8	305.5	272.9	312.7	216.3
						235.6	228.3

*Estimate

TABLE 4. BEACH WIDTHS, SELECTED BEACHES, OAHU

Beach	Width in feet at MLLW								
	3-5/62	6-8/62	10-11/62	1-3/63	4-5/63	8/63	9-11/72	1-3/72	6-7/72
Hauula		82	82	77	72	76	68	75	72
Punaluu		109	137	125	118	98	140	154	140
Lanikai	101	108	103	120	78	122	142	139	124
Makapuu	139	167	177	155	130	133	121	104	131
Kahala		30	25	38	31	41	49	49	60
Ewa	99	105	101	78	89	87	110	105	110
Pokai Bay	135	255	238	207	230	250	238	230	235
Makaha	195	243	183	93	188	224	243	146	222
Camp Erdman		175	115	144	140	135	147	148	154
Maialua		186	190	202	228	207	232	212	227
Kawailoa		128	82	104	109		107	79	112
Sunset	138	228	150	216	196	220	172	170	165

The volume of the Camp Erdman beach has remained fairly constant also. Some of the new measurements show an increase and some a decrease, but no distinct tendency is apparent.

The beach at the center of Waialua Bay shows an increase in volume.

Kawailoa shows no tendency either toward erosion or toward accretion. The January and June, 1972 measurements showed less sand on the beach than in 1963, but the fall 1971 measurement showed a gain in volume over that of 1962.

Sunset Beach shows a definite loss in volume, with all measurements made in 1971-72 smaller than any made in 1962-63 except for May 1962.

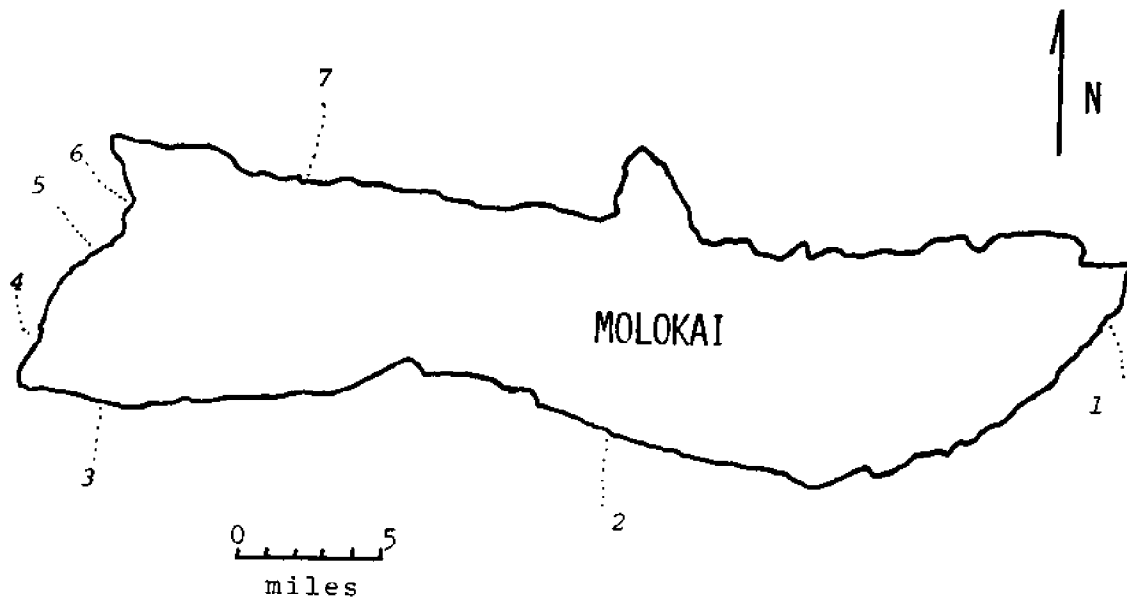
Several Oahu beaches were surveyed monthly in 1972.

MOLOKAI

Figure 3 shows the beaches that were measured on Molokai, Table 5 gives the volume of the beach sand reservoir and Table 6 shows the beach widths.

The small beach at Onealii Park shows an increase in volume over the 1962-63 measurements. Both the summer and winter measurements showed positive gains.

Kapukawahine shows a very large loss in volume since the 1962-63 period. This change was expected, since there has been a continuing sand-mining operation there. This beach should be resurveyed after the sand-mining operation is terminated in 1975.



1. KANAHA
2. ONEALII
3. KAPUKAWAHINE
4. KAMAKAIPO
5. PAPOHAKU
6. KEPUHI
7. MOOMOMI

FIGURE 3. Selected beaches, Molokai.

TABLE 5. BEACH VOLUMES, SELECTED BEACHES, MOLOKAI

Beach	Volume in 10^3 yd ³						
	6/62	8/62	11/62	3/63	6/63	9/63	1/72
Oneali	1.3	1.5	1.4	1.1	1.0	1.0	2.6
Kapukawahine	101.6	83.0	82.1	0.5	23.9	62.2	3.3
Kamakaipo		83.7	72.0	58.8	80.3	76.8	56.5
Kepuhi	39.6	46.9	38.9	28.2	40.5	44.8	43.8
Moomomi	231.8	240.7	112.4	279.8	217.4	224.8	176.8
							286.3

TABLE 6. BEACH WIDTHS, SELECTED BEACHES, MOLOKAI

Beach	6/62	8/62	Width in feet at MLW				9/63	1/72	8/72
			11/62	3/63	6/63				
Oneali	32	44	39	38	38		36	50	50
Kapukawahine	212	158	166	51	95		135	55	55
Kamakaipo		165	97	97	137		137	97	103
Kepuhi	96	232	181	150	184		209	194	185
Moomomi	375	366	255	374	395		385	335	372

Kamakaipo shows a loss of volume over the measurements made during the same seasons in 1962-63. The beachrock ledge exposed along the shoreline indicates that the erosion process had started prior to 1962.

Kepuhi shows no definite trends. The winter measurements show a gain in volume, while those made in the summer show a loss.

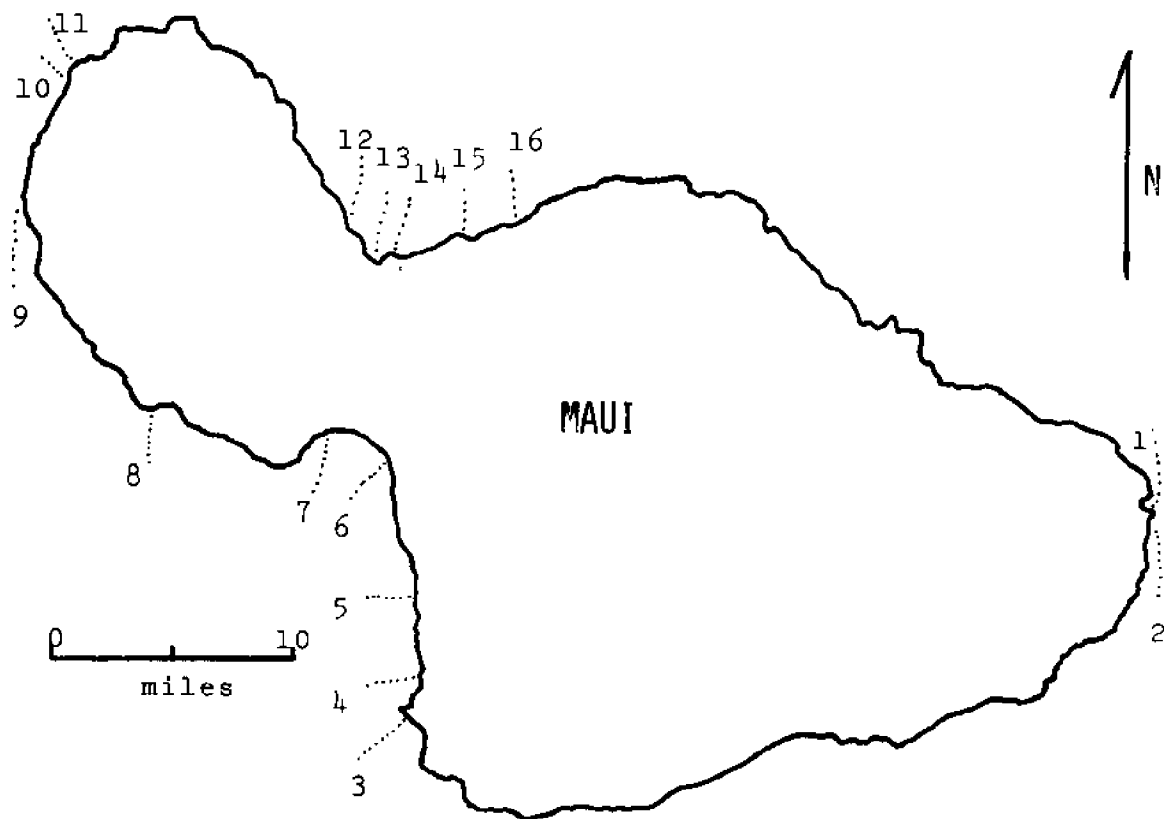
The changes in beach volume at Moomomi show no trend either toward erosion or toward accretion. However, the littoral cell is complicated by the large amount of sand that is moved around by the wind. The dunes behind the beach seem to be eroding in some places and accreting in others.

Unfortunately, it was not possible to relocate the old range at the south end of Papohaku, the site of the largest sand-mining operation in the State and the largest beach on Molokai. A record there would have been especially valuable.

MAUI

Figure 4 shows the beaches that were measured on Maui, Tables 7 and 8 give the beach volumes and widths.

Hana measurements show an increase in beach volume in January 1972 compared with the winter 1963 measurements. No measurements were made during the summer of 1972.



- | | |
|--------------------|--------------------|
| 1. HANA | 12. WAIEHU |
| 2. HAMOA | 13. KAHULUI HARBOR |
| 3. PUU O LAI | 14. KAHULUI |
| 4. MAKENA | 15. SPRECKLESVILLE |
| 5. KEAWAKAPU | 16. PAIA |
| 6. KIHEI | |
| 7. MAALAEA | |
| 8. OLOWALU | |
| 9. KAAANAPALI | |
| 10. NAPILI | |
| 11. FLEMINGS BEACH | |

FIGURE 4. Selected beaches, Maui.

TABLE 7. BEACH VOLUMES, SELECTED BEACHES, MAUI

Beach	Volume in 10 ³ yd ³							
	4/62	6/62	9/62	2/63	6/63	8-9/63	1/72	8/72
Hana	8.1	6.9	8.1	8.8	8.2	8.8	10.7	
Hamoa		29.2	28.7	24.3	25.4	26.7	23.1	
Puu O Lai	190.6	172.5	172.1	234.9	203.5	173.6	154.8	178.3
Olowalu	48.8	50.0	43.2	51.4	41.7	44.8	44.4	43.1
Kaanapali		60.0*	63.8	50.2	59.7	66.5	51.7	75.9
Napili		25.7	27.5	16.3	23.1	28.0	12.2	20.4
Flemings Beach		4.7	5.8	6.8	9.6	6.8	4.1	4.0
Waiehu	26.0	27.7	31.9	28.3	29.0	28.6	51.4	54.1
Sprecklesville	74.5	82.6	76.3	70.1	74.0	71.3	59.3	63.3
Pala	31.7	30.3	32.6	28.5	35.6	32.3	31.2	31.7

*Estimate

TABLE 8. BEACH WIDTHS, SELECTED BEACHES, MAUI

Beach	Width in feet at MLLW						
	4/62	6/62	9/62	2/63	6/63	8-9/63	1/72
Hana	120	92	120	102	95	114	105
Hamao		195	175	132	150	180	167
Puu O Lai	165	167	153	242	180	149	155
Olowalu	74	72	59	73	68	60	64
Kaanapali			181	140	150	164	125
Napili		121	127	96	131	128	85
Flemings Beach		54	72	78	123	68	70
Waiehu	55	52	60	58	57	56	73
Sprecklesville	152	152	155	140	154	152	110
Paia	99	90	102	85	153	101	93

Hamoia measurements show a loss in volume in January 1972 compared with 1962-63 winter measurements. The 1972 winter volume is the smallest ever measured at Hamoia.

The winter 1972 measurement at Puu O Lai shows a large decrease in volume as compared with the 1963 volume. However, by August the beach volume was greater than in 1963. Thus no definite trends are apparent.

Both summer and winter measurements show a loss of volume at Olowalu.

Kaanapali shows an increase in volume over 1962-63 in both the summer and winter. The change is most apparent in the August measurement.

Napili has suffered a loss in beach volume since the 1962-63 period. The winter 1972 measurement shows the smallest volume ever measured there.

Flemings Beach shows a decrease in volume over the last ten years.

Waiehu shows a significant increase in volume for both the winter and summer measurements.

Sprecklesville continues to suffer the erosion problems noted a few decades ago. Both of the 1972 measurements show smaller volumes than during the 1962-63 period.

Paia shows no significant change in the last ten years. The 1972 beach volume measurements fall in the middle of the seasonal range determined by the 1962-63 measurements.

HAWAII

As previously mentioned, the beaches on Hawaii were not remeasured during this study. However, during the planning of the study one trip was made to Hawaii, at which time measurements were made at the two black sand beaches (Kaimu and Punaluu) on the southeast coast. Figure 5 shows the location of the black sand beaches on Hawaii and Tables 9 and 10 give their volumes and widths. The measurements were made to determine whether the two beaches were eroding as badly as most people think. Both beaches showed some erosion has taken place. At Kaimu, volume in 1971 was less than during any of the previous measurements. At Punaluu, volume was less during the summer of 1971 than during the same periods in 1962-63, but the 1971 volume still fell within the range of values determined earlier.

Long-Term Changes

To ascertain any major long-term change in the total beach volume of any of the islands, the volumes of all beaches were summed for each island. Although this volume is certainly not the total volume of the beach sand reservoir for the whole island, the geographic distribution and averaging effect of the selected beaches is such that these values should point up any major trends. Figure 6 is a plot of beach-sand volume on each island studied versus time.

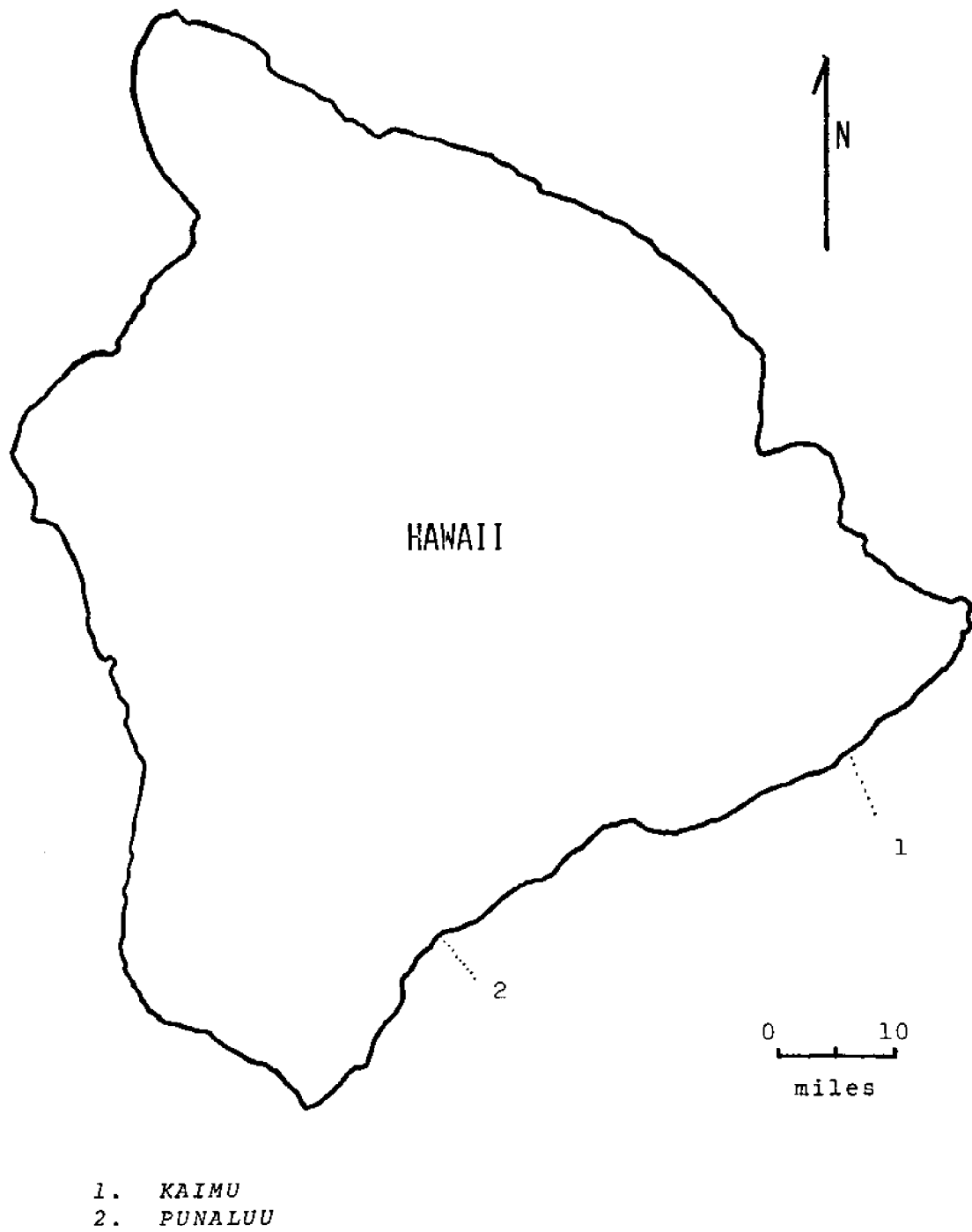


FIGURE 5. Selected beaches, Hawaii. Kaimu and Punaluu are black-sand beaches.

TABLE 9. BEACH VOLUMES, BLACK SAND BEACHES, HAWAII

Beach	Volume in 10^3 yd ³					
	6/62	9/62	1/63	4/63	7/63	7/71
Kaimu	9.6	8.9	4.3	9.0	4.7	1.8
Punaluu	10.9	8.4	9.1	8.7	10.4	8.6

TABLE 10. BEACH WIDTHS, BLACK SAND BEACHES, HAWAII

Beach	6/62	Width in feet at MLLW				
		9/62	1/63	4/63	7/63	7/71
Kaimu	95	91	72	77	90	75
Punaluu	111	105	105	103	113	102

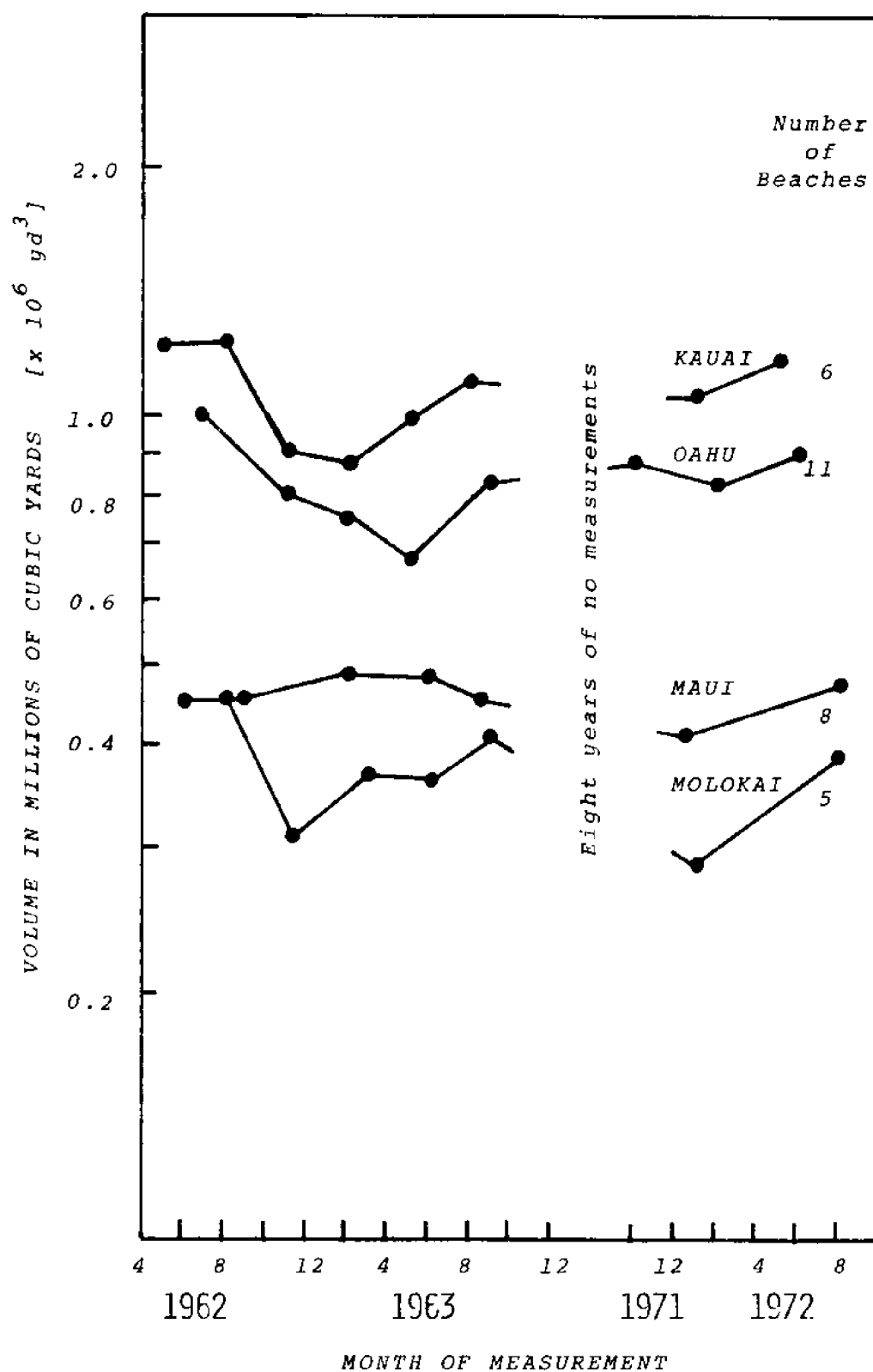


FIGURE 6. Size of selected beach-sand reservoirs, Hawaiian Islands. Measurements of 1962-63 compared with those of 1971-72.

Variations in the plot can be correlated with seasonal fluctuations. It is readily apparent that there has been no major long-term erosion or accretion on any of the islands. Although there were no major island-wide long-term changes, there were some significant local changes. It is interesting to note that these individual gains and losses tend to balance one another for each island.

Acknowledgments

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